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Modelling of Micro-structure from 3D X-ray CT of Fiber Composite

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Wind turbine blades are subjected to a high number of fatigue load cycles during their long life of 20-30 years. As a consequence, fatigue damage evolution in the uni-directional (UD) composite material, used for the main load carrying spars, is one of the main limiting factors against designing longer blades. Since fatigue damage evolution in UD composites is not well understood, this study considers gaining understanding on how to simulate fatigue damage in order to reduce the high safety factors in the future.

For the considered UD glass fibre composite, each UD layer is stitched to a thin transverse backing layer. The fatigue damage initiates in the backing layers, through debonding, and propagates into the UD bundles.

The cracks in the backing layer are mainly observed to propagate into the UD layer at locations where the backing bundles are intertwining and in direct contact with the UD bundles. For this reason a realistic model should include the presence of the thin backing layer, even though it does not have any particular effect on the material stiffness. 10

3D x-ray computed tomography (3D XCT) was used to obtain a 3D image of the internal micro-structure of the considered UD composite. The resolution in the considered scans is sufficient to visually distinguish single fibres, but too low to use a simple blob detection algorithm to locate them. Using a dictionary based segmentation algorithm makes it possible to extract the individual fibre centre lines, and transfer them into the finite element software ABAQUS for further analysis. From the 3D XCT scans it is possible to visualize individual broken fibres, opening the possibility of introducing broken fibres at realistic locations in the model. In addition, these observations can serve as a good way of validating micro-structural fatigue damage models.